PAPER • **OPEN ACCESS**

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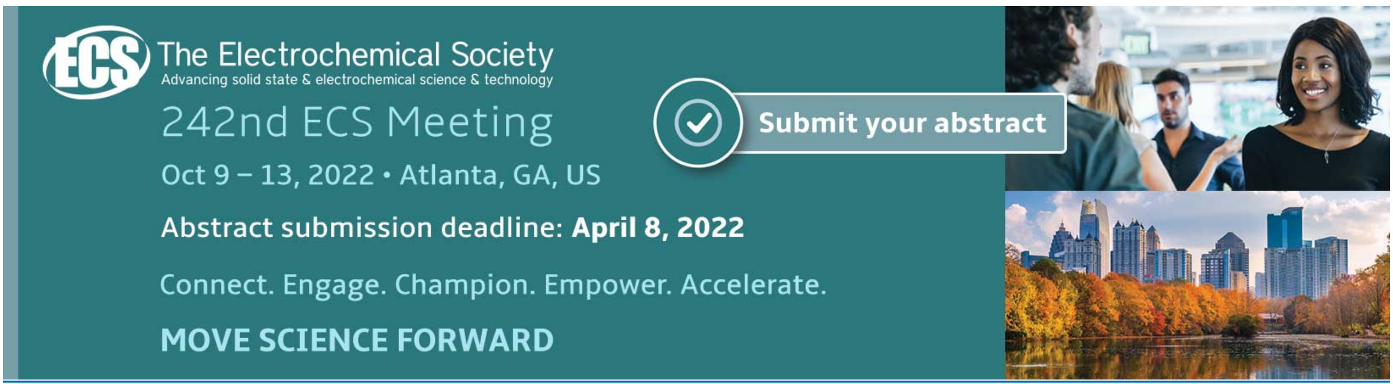
To cite this article: O Versolato *et al* 2020 *J. Phys.: Conf. Ser.* **1412** 192006



Spectroscopic investigations of YAG-laser-driven microdroplet-tin plasma sources of extreme ultraviolet radiation for nanolithography

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Synopsis Highly charged tin ions are the sources of extreme ultraviolet (EUV) light at 13.5-nm wavelength in laser-produced transient plasmas for next-generation nanolithography. Generating this EUV light at the required power, reliability, and stability however presents a formidable task that combines industrial innovations with challenging scientific questions. We will present work on the spectroscopy of tin ions in and out of YAG-laser-driven plasma and present a surprising answer to the key question: what makes that light?

Extreme ultraviolet (EUV) at 13.5-nm wavelength light will soon be used for state-of-the-art nanolithography. Current lithography technology uses 193-nm light; EUV wavelengths enable higher resolution. This step, towards using EUV light, is crucial for continuing the miniaturization of the features on chips as represented by Moore's law. To produce the required EUV light, highly charged tin ions are bred in laser-driven transient, dense plasmas. Near the 13.5 nm wavelength that can efficiently be reflected from available multilayer optics, the EUV spectrum of highly charged Sn ions is dominated by intense unresolved transition arrays (UTAs) from the resonance transitions $4p^6 4d^m$ - $4p^5 4d^{m+1}$ + $4d^{m-1}$ 4f in Sn^{8+}-Sn^{14+} (see figure) although other, more highly excited states also significantly contribute. UTAs from serendipitously aligned, strongly interacting configurations from several Sn charge states contribute to a remarkably efficient production of EUV. A detailed understanding of the complex atomic structure of tin ions is of a prerequisite to establish and understand the fundamental atomic physics limitations to the conversion efficiency of drive laser light into useful EUV radiation. In this contribution, we will present work on the spectroscopy of tin ions both in [1] and out [2,3] of the laser-driven plasma. Detailed comparisons are made with ongoing large-scale simulation efforts on the YAG-laser-produced plasma.

These studies enable finding a surprising answer to the key question: what makes that light?

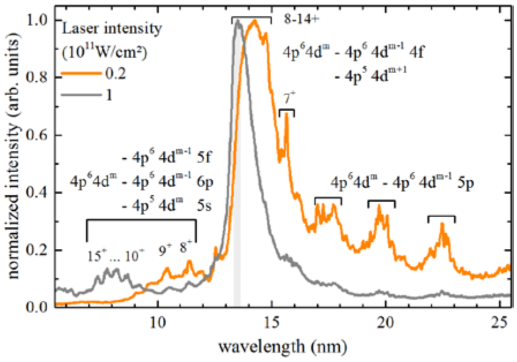

Figure 1. Emission spectra resulting from a tin droplet illuminated with a Nd:YAG laser beam at two intensities. Emission features attributed to the various Sn charge states are labeled (m is an integer between 0 and 6).

References

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